

CLAIMS

What is claimed is:

1. An optical apparatus, comprising:

a bottom surface and walls formed on a first substrate and substantially defining a detection volume and an upper opening thereof;
an optical waveguide having an end face, the optical waveguide aligned substantially parallel to the first substrate and positioned so that at least a portion of light emerging from the end face enters the detection volume; and
a photodetector having an active area on a detector substrate, the detector substrate mounted on the first substrate so as to cover at least a portion of the upper opening of the detection volume with at least a portion of the active area exposed to the detection volume.

2. The apparatus of Claim 1, wherein the walls are formed at least in part by a ridge protruding from the substrate.

3. The apparatus of Claim 1, wherein the walls are formed at least in part by a recessed area formed on the substrate.

4. The apparatus of Claim 1, wherein the optical waveguide is formed on the first substrate.

5. The apparatus of Claim 4, wherein the walls of the detection volume are formed at least in part from material used to form the cladding of the optical waveguide.

6. The apparatus of Claim 4, wherein the walls of the detection volume are formed at least in part by material used to form the core of the optical waveguide.

7. The apparatus of Claim 6, wherein the core material forming the core of the optical waveguide and partly forming the walls of the detection volume is non-contiguous.

8. The apparatus of Claim 1, wherein the optical waveguide is formed on a waveguide substrate, and the optical waveguide is mounted on the first substrate.

- 1 9. The apparatus of Claim 8, wherein light emerging from the end face of the optical
2 waveguide may enter the detection volume through a passage through one of the
3 walls thereof.
- 4 10. The apparatus of Claim 8, wherein light emerging from the end face of the optical
5 waveguide may enter the detection volume through a substantially transparent
6 segment of one of the walls thereof.
- 7 11. The apparatus of Claim 8, further comprising a reflective coating on an area of the
8 first substrate where light emerging from the end face of the optical waveguide
9 may enter the detection volume.
- 10 12. The apparatus of Claim 8, further comprising a reflective coating on the waveguide
11 substrate at the end face of the optical waveguide.
- 12 13. The apparatus of Claim 1, further comprising substantially transparent embedding
13 material substantially filling the detection volume, substantially covering the end
14 face of the optical waveguide, and substantially filling an optical path between the
15 end face of the optical waveguide and the detection volume.
- 16 14. The apparatus of Claim 13, wherein at least one wall of the detection volume has
17 a passage therethrough for admitting liquid embedding material into the detection
18 volume.
- 19 15. The apparatus of Claim 1, wherein the detection volume is substantially sealed by
20 mounting of the photodetector over the upper opening of the detection volume.
- 21 16. The apparatus of Claim 15, further comprising a substantially flat substantially
22 contiguous upper mounting surface surrounding the upper opening of the
23 detection volume, wherein the upper mounting surface engages the photodetector
24 to substantially seal the detection volume.
- 25 17. The apparatus of Claim 15, further comprising multiple substantially flat
26 substantially coplanar upper mounting surfaces arranged around the upper

1 opening of the detection volume, wherein the upper mounting surfaces engage the
2 photodetector and gaps between the upper mounting surfaces are substantially
3 filled with at least one of adhesive and solder, thereby substantially sealing the
4 detection volume.

5 18. The apparatus of Claim 1, further comprising a reflective coating on at least a
6 portion of the bottom surface of the detection volume.

7 19. The apparatus of Claim 18, wherein the reflective coating comprises a metallic
8 coating.

9 20. The apparatus of Claim 19, wherein the metallic reflective coating serves as an
10 electrical contact for the photodetector.

11 21. The apparatus of Claim 1, wherein at least a portion of the inner face is tilted
12 upward.

13 22. The apparatus of Claim 1, wherein at least a portion of the inner face is adapted
14 for reducing optical feedback from the detection volume through the end face into
15 the optical waveguide.

16 23. The apparatus of Claim 1, wherein the end face of the optical waveguide is tilted
17 downward so that light emerging from the end face is refracted toward the
18 photodetector.

19 24. A method, comprising:
20 forming a bottom surface and walls on a first substrate, thereby substantially
21 defining a detection volume and an upper opening thereof;
22 positioning an optical waveguide substantially parallel to the first substrate so that
23 at least a portion of light emerging from an end face of the optical waveguide
24 enters the detection volume;
25 mounting a detector substrate on the first substrate so as to cover at least a
26 portion of the upper opening of the detection volume with at least a portion of
27 an active area on the detector substrate exposed to the detection volume.

- 1 25. The method of Claim 24, wherein the walls formed at least in part by a ridge
2 protruding from the substrate.
- 3 26. The method of Claim 24, wherein the walls are formed at least in part by a
4 recessed area formed on the substrate.
- 5 27. The method of Claim 24, further comprising forming the optical waveguide on the
6 first substrate.
- 7 28. The method of Claim 27, wherein the walls of the detection volume are formed at
8 least in part from material used to form the cladding of the optical waveguide.
- 9 29. The method of Claim 27, wherein the walls of the detection volume are formed at
10 least in part by material used to form the core of the optical waveguide.
- 11 30. The method of Claim 29, wherein the core material forming the core of the optical
12 waveguide and partly forming the walls of the detection volume is non-contiguous.
- 13 31. The method of Claim 27, further comprising:
14 forming bottom surfaces and walls on a common substrate wafer, thereby
15 substantially defining multiple detection volumes concurrently;
16 forming multiple corresponding optical waveguides concurrently on the common
17 substrate wafer; and
18 dividing the substrate wafer into individual substrates having thereon at least one
19 detection volume and corresponding optical waveguide.
- 20 32. The method of Claim 24, further comprising:
21 forming the optical waveguide on a waveguide substrate; and
22 mounting the optical waveguide on the first substrate.
- 23 33. The method of Claim 32, further comprising forming a passage through one of the
24 walls of the detection volume for admitting into the detection volume at least a
25 portion of the light emerging from the end face of the optical waveguide.

- 1 34. The method of Claim 32, further comprising forming a substantially transparent
2 segment of one of the walls of the detection volume for admitting into the detection
3 volume at least a portion of the light emerging from the end face of the optical
4 waveguide.
- 5 35. The method of Claim 32, further comprising forming a reflective coating on an area
6 of the first substrate where light emerging from the end face of the optical
7 waveguide may enter the detection volume.
- 8 36. The method of Claim 32, further comprising forming a reflective coating on the
9 waveguide substrate at the end face of the optical waveguide.
- 10 37. The method of Claim 24, further comprising substantially covering the end face of
11 the optical waveguide, substantially filling the detection volume, and substantially
12 filling an optical path between the end face of the optical waveguide and the
13 detection volume, with substantially transparent embedding material.
- 14 38. The method of Claim 37, further comprising forming a passage through at least
15 one wall of the detection volume admitting liquid embedding material into the
16 detection volume.
- 17 39. The method of Claim 24, wherein the detection volume is substantially sealed by
18 mounting of the photodetector over the upper opening of the detection volume.
- 19 40. The method of Claim 39, further comprising forming a substantially flat
20 substantially contiguous upper mounting surface surrounding the upper opening of
21 the detection volume, wherein the upper mounting surface engages the
22 photodetector to substantially seal the detection volume.
- 23 41. The method of Claim 39, further comprising forming multiple substantially flat
24 substantially coplanar upper mounting surfaces arranged around the upper
25 opening of the detection volume, wherein the upper mounting surfaces engage the
26 photodetector and gaps between the upper mounting surfaces are substantially

1 filled with at least one of adhesive and solder, thereby substantially sealing the
2 detection volume.

3 42. The method of Claim 24, further comprising forming a reflective coating on at least
4 a portion of the bottom surface of the detection volume.

5 43. The method of Claim 42, wherein the reflective coating comprises a metallic
6 coating.

7 44. The method of Claim 43, wherein the metallic reflective coating serves as an
8 electrical contact for the photodetector.

9 45. The method of Claim 24, wherein at least a portion of the inner face is tilted
10 upward.

11 46. The method of Claim 24, further comprising adapting at least a portion of the inner
12 face is for reducing optical feedback from the detection volume through the end
13 face into the optical waveguide.

14 47. The method of Claim 24, wherein the end face of the optical waveguide is tilted
15 downward so that light emerging from the end face is refracted toward the
16 photodetector.

17 48. An optical apparatus, comprising:
18 a bottom surface and walls formed on a first substrate and substantially defining a
19 detection volume and an upper opening thereof;
20 a semiconductor laser having a first laser end face and a second laser end face,
21 the semiconductor laser aligned substantially parallel to the first substrate and
22 positioned so that at least a portion of light emerging from the first laser end
23 face enters the detection volume; and
24 a photodetector having an active area on a detector substrate, the detector
25 substrate mounted on the first substrate so as to cover at least a portion of the
26 upper opening of the detection volume with at least a portion of the active area
27 exposed to the detection volume.

- 1 49. The apparatus of Claim 48, further comprising an optical waveguide positioned so
2 that at least a portion of light emerging from the second laser end face enters the
3 optical waveguide.
- 4 50. The apparatus of Claim 49, wherein the optical waveguide comprises a planar
5 optical waveguide formed on the first substrate.
- 6 51. The apparatus of Claim 49, wherein the optical waveguide is mounted on the first
7 substrate.
- 8 52. The apparatus of Claim 49, wherein at least a portion of the light emerging from
9 the second laser end face enters the optical waveguide through an end face
10 thereof.
- 11 53. The apparatus of Claim 49, wherein at least a portion of the light emerging from
12 the second laser end face enters the optical waveguide by transverse-coupling
13 thereto.
- 14 54. The apparatus of Claim 48, wherein the semiconductor laser is formed on the first
15 substrate.
- 16 55. The apparatus of Claim 48, wherein the semiconductor laser is formed on a laser
17 substrate and mounted on the first substrate.